NASA TECH BRIEF

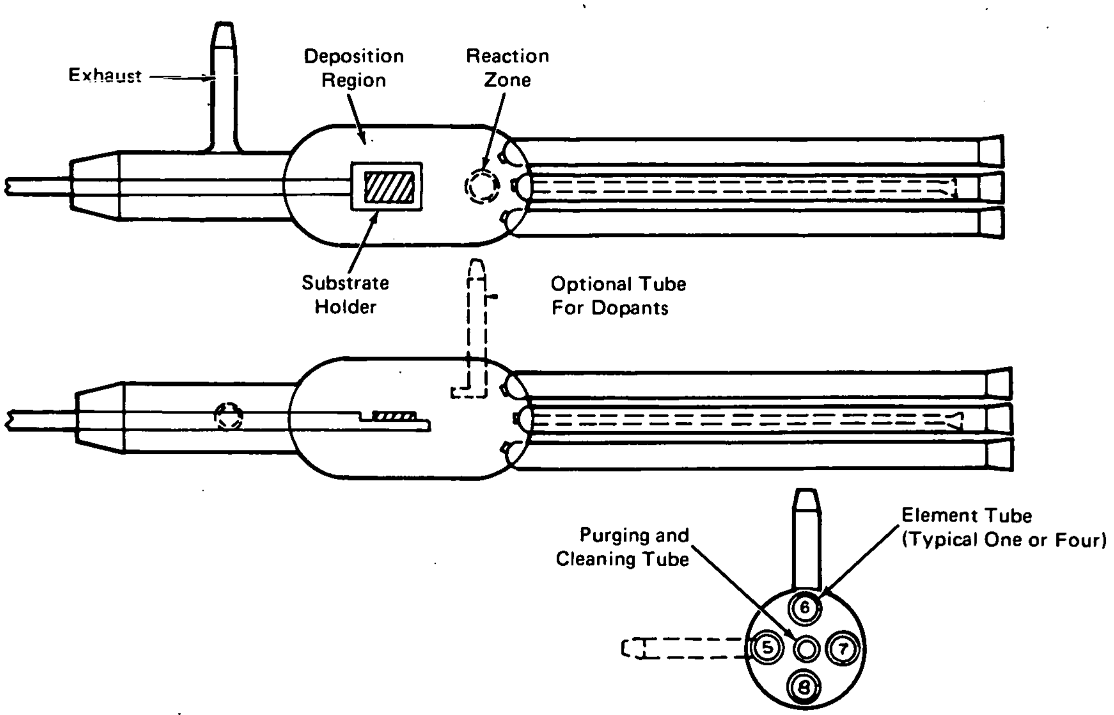
Langley Research Center

Vapor Phase Growth of Group III, IV, and V Compounds By HC1 Transport of Elements

This is a technique of vapor phase epitaxial growth of group III, IV, and V binary, ternary, or quaternary compounds by HCl transport of the constituent elements or dopants.

This technique utilizes all the constituents of the alloy system in their elemental form, which are readily available in high purity. The transport of these elements by an HCl + H_2 carrier gas facilitates their transport as sub-chlorides. The elements are kept at temperatures below their boiling point (or sublimation temperature) but at a high enough temperature for their quick reaction with the HCl carrier gas. Enough of the surface of the elements must be exposed to the carrier gas to ensure that unreacted HCl does not reach the reaction chamber. The rate of transport of elements can then be accurately controlled by adjusting the rate of flow or dilution of the carrier gas flowing over them. A typical range of concentration used is 1% to 10% of HCl by volume mixed with hydrogen. The volume of carrier gas flowing over each element is usually kept below 300 cc/min.

The growth apparatus, shown in the illustration, consists of an eight-zone horizontal furnace that uses independently controlled resistance heating units of lengths varying from four to eight inches each. The elements are put in graphite boats and then inserted into the appropriate temperature zones.



(continued overleaf)

The growth tube is made of fused quartz and consists of four separate tubes for each of the elements (or dopants) of the alloy system. The inside of the growth tube may be coated with carbon to prevent the impurities in silica from diffusing into the crystal being grown and also to shield the silica tube from reacting with highly abrasive compounds like the chlorides of aluminum. The versatility of the system can be increased by transporting the dopants through a side tube (shown by the dotted lines) in which case a vertical heater is added to the furnace. Another fine tube is provided for purging and cleaning the system after growth by flowing HCl gas through it while the element tubes carry pure hydrogen. During the growth, however, only hydrogen is passed through the purging and cleaning tube at a rate of about 100 cc/min. Any dopants in the gaseous form like H_2Se or NH_3 may also be passed through this tube. All five longitudinal tubes feed into the reaction zone which leads to the deposition region. The substrate is a single crystal oriented in the $< 100 >$ direction and mounted on a fused quartz substrate holder. The exhaust zone heater, which helps etch out the deposition from inside the tube during the cleaning process, is used for preheating the substrate before it is inserted into the growth zone. The exhaust gases are bubbled out through an inert low-vapor-pressure oil.

After the system has been purged with hydrogen at the equilibrium temperature distribution, the carrier gas, $HCl + H_2$, is passed over the arsenic for 5-10 minutes. At this time the substrate is introduced into the deposition growth region, and the flow continued for about ten minutes. Crystal growth is then started by also passing the carrier gas over the gallium. Substitution of other elements for the Ga or As is accomplished by flowing the carrier gas over the desired elements. By changing the carrier gas flow rates over the various elements, the crystal composition can be graded and controlled to almost any desired product. Since the ratio of the elements in the grown crystal are not the same as the ratio of the flow rates over the respective elements, the system must be calibrated to determine composition as a function of the various flow rates.

Note:

No additional documentation is available. Specific questions, however, may be directed to:

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Patent status:

Inquiries concerning rights for the commercial use of this invention should be addressed to:

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